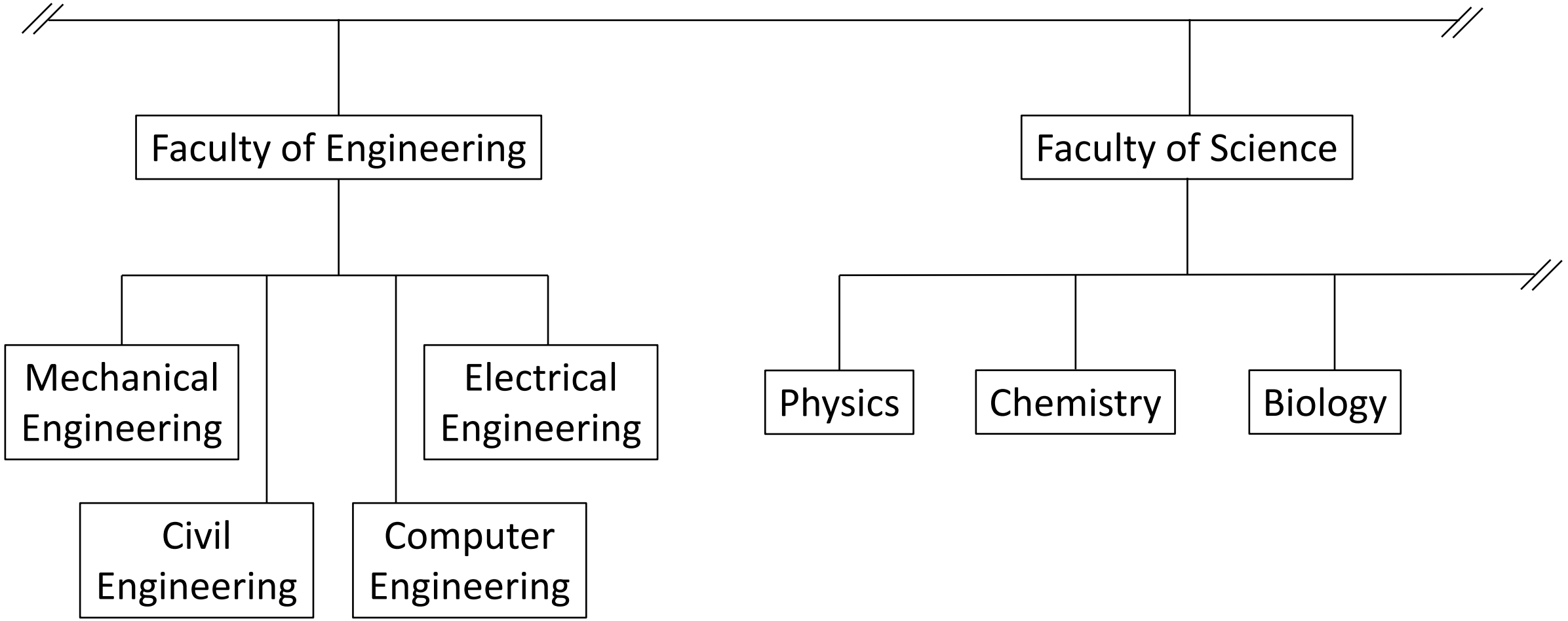
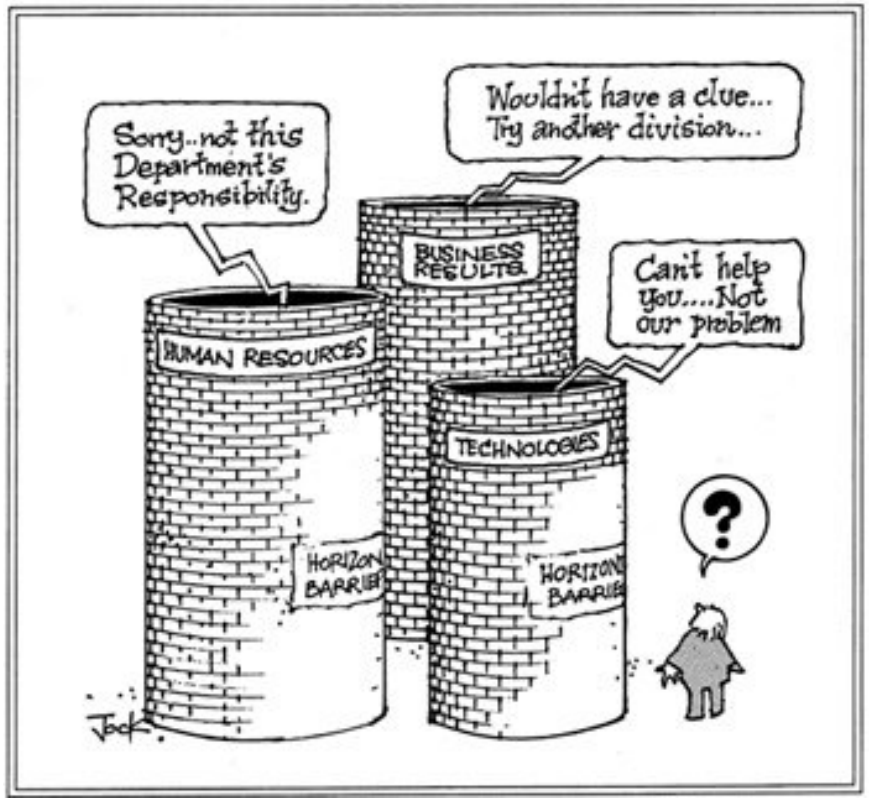
Quantum Science Centres Across Canada and Around the World

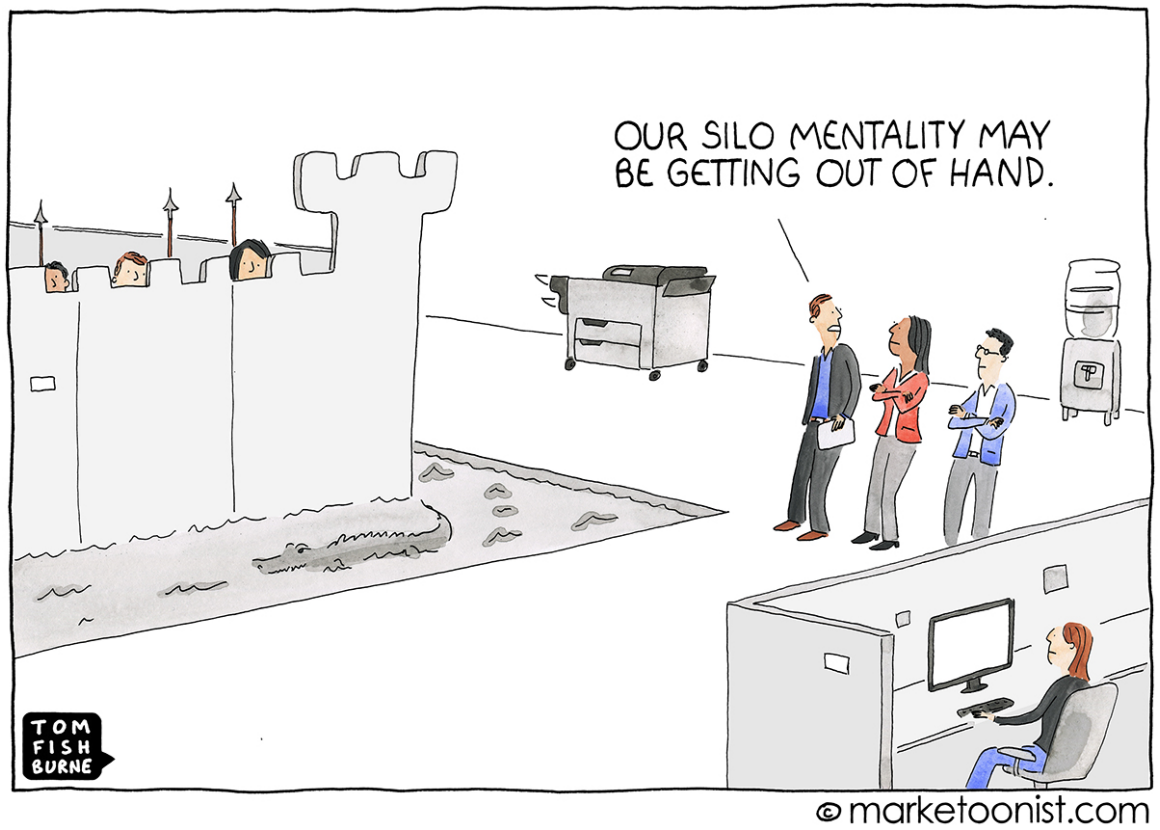
Iain McKenzie

Typical University Organization Schemes



Organizational Silos in Business and Academia



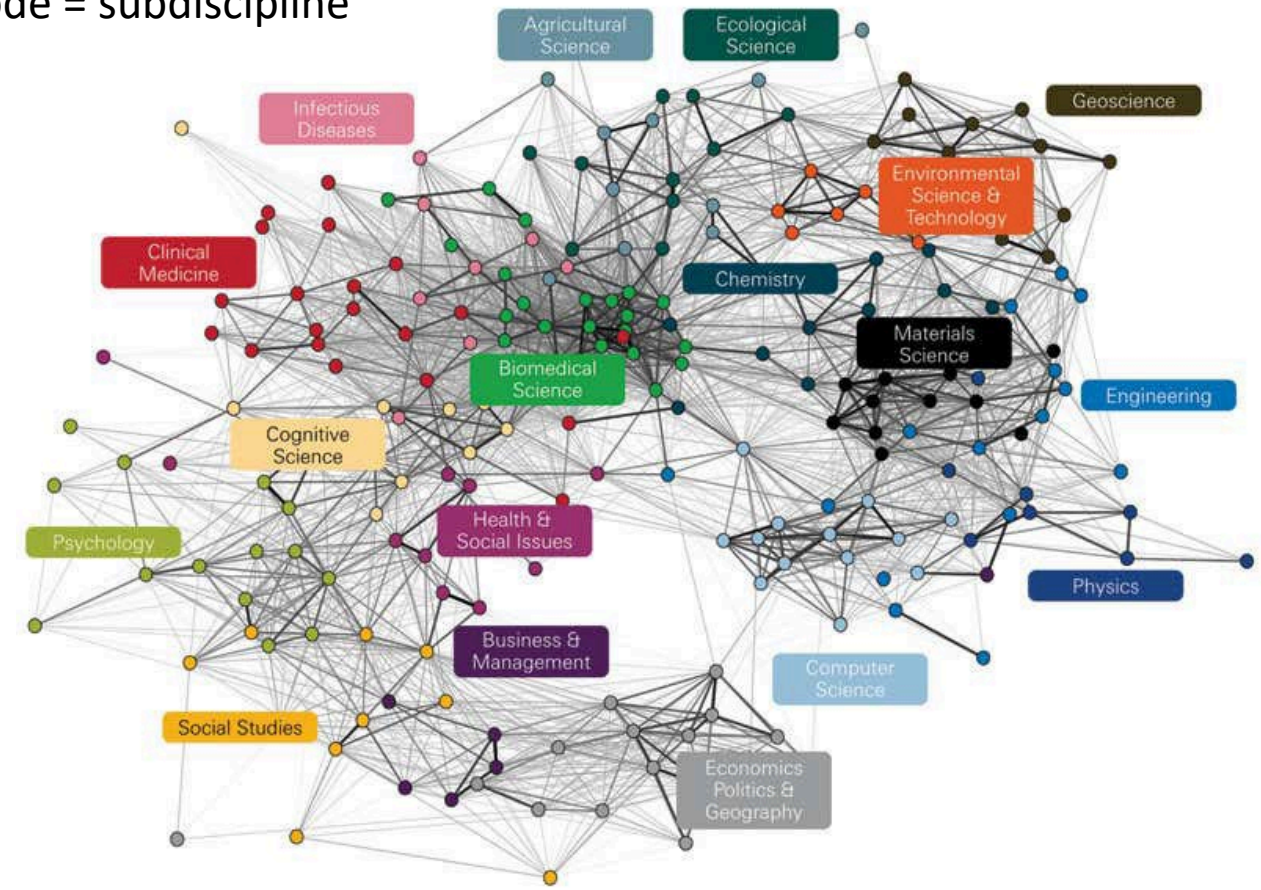


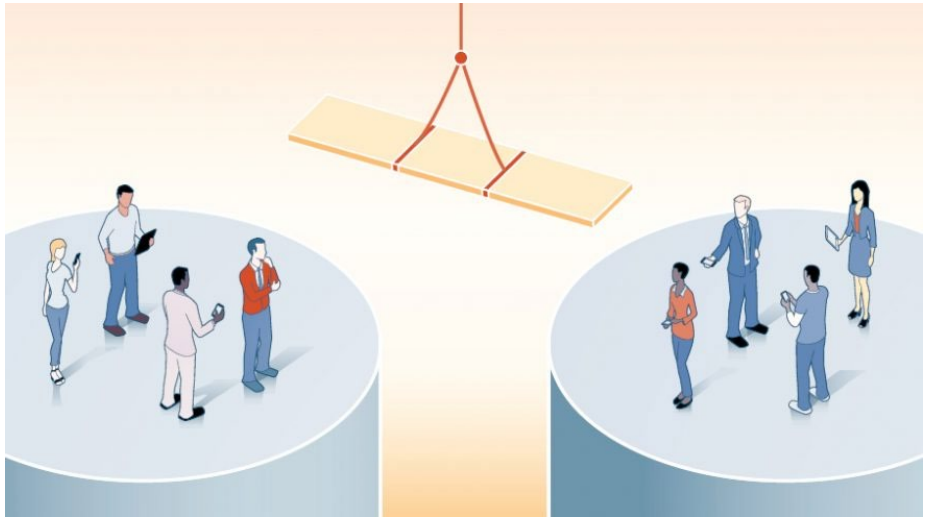
Problems arise when individual departments become so focused on their own priorities that they lose track of the organization's wider needs.

Inefficiencies and missed opportunities

Breaking Down Silos – Encouraging Interdisciplinary Science

Map of journal cross-citations
Node = subdiscipline

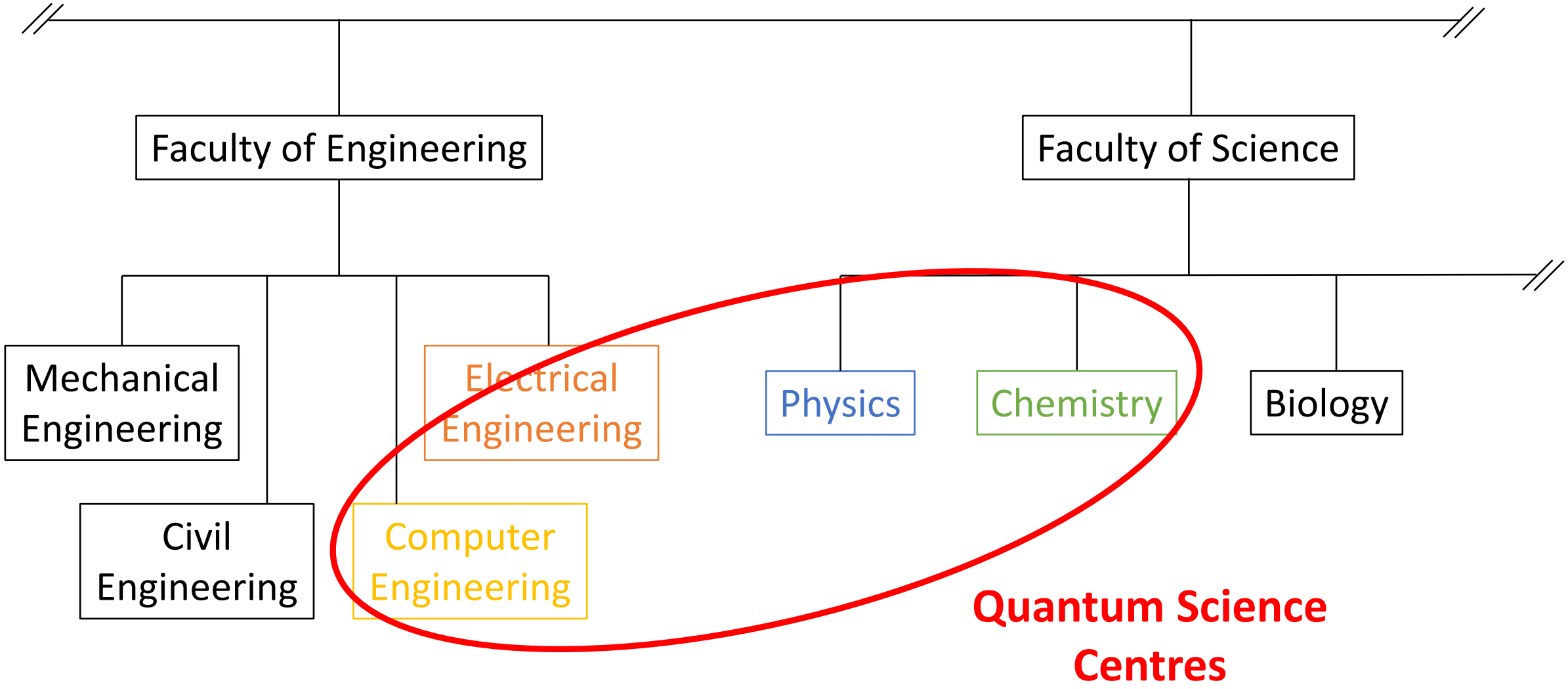


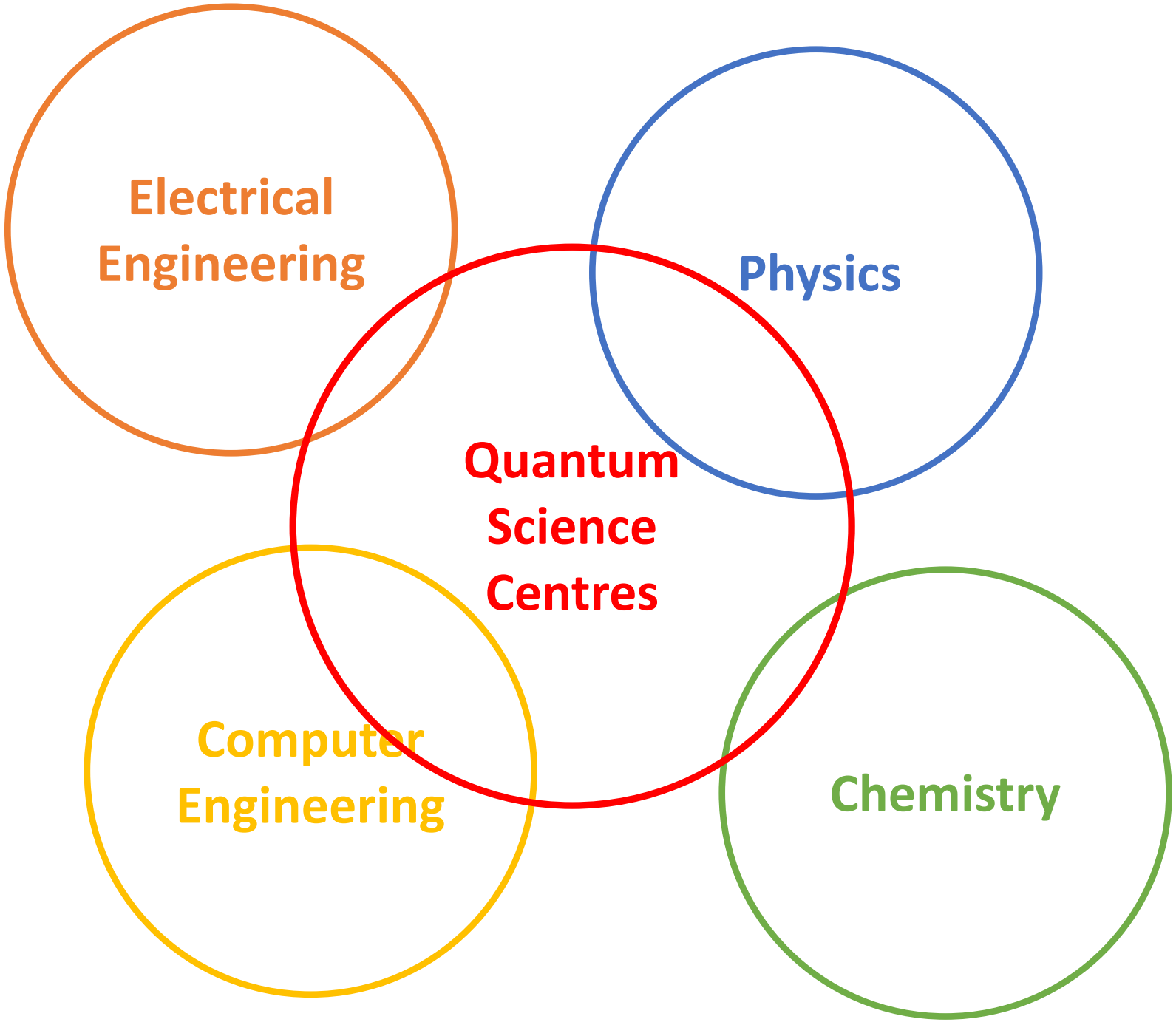


- Get executive buy-in
- Bring teams together
- Create a unified vision
- Develop shared goals
- Incentivize collaboration

https://www.newscientist.com/article/mg20928002-100-open-your-mind-to-interdisciplinary-research/

Quantum Science Centres Vs. Typical University Organization Schemes




Electrical Engineering
Physics
Quantum Science Centres
Computer Engineering
Chemistry

Canada

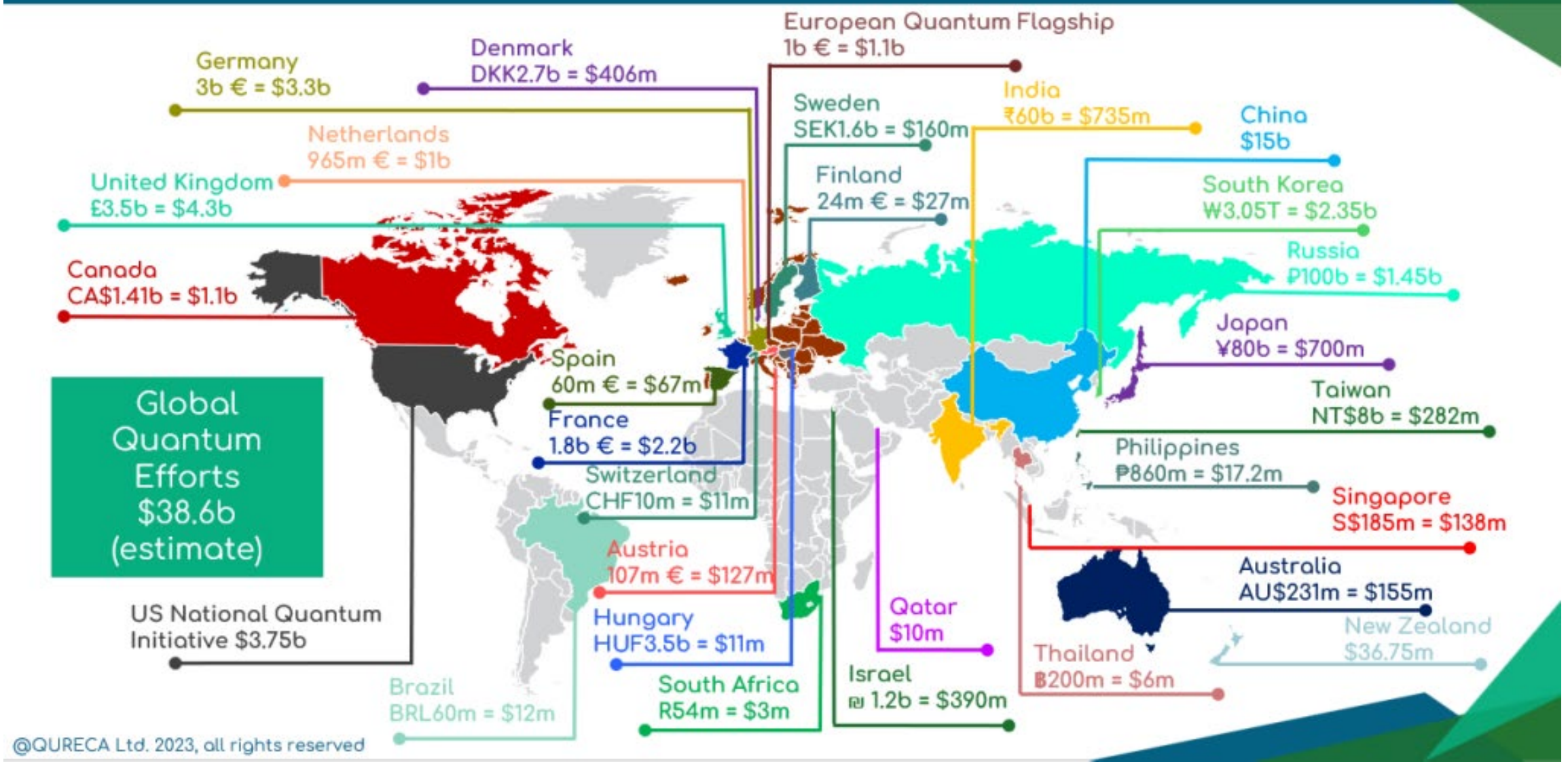
- UBC Stewart Blussom Quantum Matter Institute https://qmi.ubc.ca/
- U. Calgary Institute for Quantum Science and Technology https://iqst.ucalgary.ca/
- U. Saskatchewan quanTA: Centre for Quantum Topology and Its Applications https://artsandscience.usask.ca/quanta/index.php
- U. Waterloo Institute for Quantum Computing https://uwaterloo.ca/institute-for-quantum-computing/
- U. Toronto Centre for Quantum Information and Quantum Control https://cqiqc.physics.utoronto.ca/
- U. Sherbrooke Institut Quantique https://www.usherbrooke.ca/iq/en/

Worldwide

- ORNL Quantum Science Center https://qscience.org/about/
- Fermilab Superconducting Quantum Materials and Systems Center https://sqmscenter.fnal.gov/
- LBNL Quantum Information Science and Technology https://cs.lbl.gov/what-we-do/quantum-computing/
- LLNL Quantum Science and Technology https://quantum.llnl.gov/
- Munich Center for Quantum Science and Technology https://www.mcqst.de/research/overview/
- DESY Center for Quantum Technology and Applications (CQTA) https://quantum-zeuthen.desy.de/
- CERN Quantum technology initiative https://quantum.cern/

And more……

Quantum effort worldwide



https://qureca.com/overview-of-quantum-initiatives-worldwide-2023/

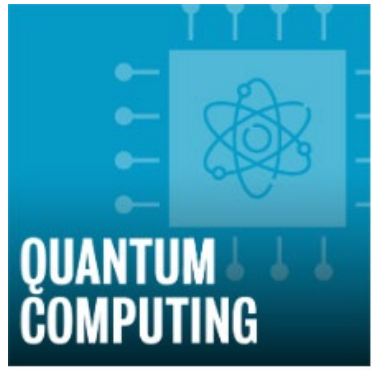
What can TRIUMF learn from Quantum Science Centres in Canada and around the world?

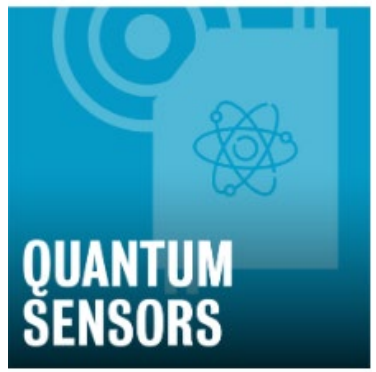
- Similar visions – quantum science as a unifying
- Similar organizational structures (cross departmental)
- Varying emphasis on five principal quantum technologies reflecting the underlying strengths of the organization.
- Rely on the nebulous definition of ‘quantum’ to include a wide range of science.

How effective are they in practice?

UNIVERSITY OF WATERLOO

IQC Institute for Quantum Computing





Coherent Spintronics Group

The Coherent Spintronics Group focuses on furthering the science and technology of quantum devices by developing prototypes and quantum control methods necessary for scalable Quantum Information Processing (QIP).

Learn More

Digital Quantum Matter Lab

The Digital Quantum Matter laboratory is dedicated to researching and designing quantum information processing devices. The ultimate goal of the group will be to build a fully general quantum computer.

Learn More

Engineered Quantum Systems Laboratory

In the Engineered Quantum Systems Laboratory, we study light-matter interactions using superconducting microwave circuits for exploring new physics in the quantum regime.

Learn More

Functional Quantum Materials Group

The Functional Quantum Materials Group's research focuses on a particular aspect of the electrons – their spin degrees of freedom.

Learn More

Jamison Lab

The Jamison Lab studies ultracold matter, cooling atoms and molecules to within a few billionths of a degree of absolute zero. We use this ultracold stuff to study the complexities of many-body quantum systems and quantum chemistry.

Learn More

Nano-Photonics and Quantum Optics Lab

The Nano-Photonics and Quantum Optics Lab focuses on development and studies of novel forms of light-matter interactions and their applications using quantum optics and nanoscale photonic structure.

Learn More

Nuclear Magnetic Resonance (NMR) Laboratory

The liquid state laboratory (Chemistry 2, room 170) houses all of the test equipment and tools necessary to design, construct, troubleshoot and repair RF instruments. Professor Bill Power's chemistry laboratory is available for use for sample preparation.

Learn More

Optical Quantum Communication Theory Group

The Optical Quantum Communication Theory Group explores the interface between quantum communication theory and quantum optical implementations.

Learn More

Quantum Encryption and Science Satellite (QEYSSAT)

The Quantum Encryption and Science Satellite (QEYSSat) plans to demonstrate quantum key distribution (QKD) in space. QKD is a technology that creates virtually unbreakable encryption codes and will provide Canada with secure communications in the age of quantum computing.

Learn More

Quantum Information with Trapped Ions

The Laboratory for Quantum Information with Trapped Ions (QITI) studies interaction between quantum degrees of freedom in a laser-cooled trapped ion system. QITI aims to create a flexible quantum system, with control at the level of individual particles for studying problems in quantum many-body physics and computation.

Learn More

Quantum Innovation (QuIN) Lab

The Quantum Innovation (QuIN) Lab presents the lessons from the study of carbon nanotubes and exciton-polaritons, and gives perspectives and current progress on strategic action plans for the future.

Learn More

Quantum Interactions Theory Group

The Quantum Interactions Theory Group is a theoretical research group run by Christine Muschik.

The group develops novel tools for investigating and engineering light-matter interactions with applications in the field of quantum information science. Their work involves close collaborations with experimental groups and focuses particularly on finding new protocols for realizing (i) quantum networks and (ii) quantum simulations of models from high energy physics.

Learn More

Quantum Materials and Devices Lab

Quantum Materials and Devices Lab ("The Tsen Group") aims to uncover new physical phenomena in quantum materials with reduced dimensionality, and incorporate these materials in novel (opto)electronic devices for quantum information technology.

Learn More

Quantum Optics and Quantum Information Lab

The research interests of the Quantum Optics and Quantum Information Lab are in:

- experimental quantum optics,
- nonlinear optics,
- state reconstruction and measurement, and
- interferometry.

Learn More

Quantum Photonic Devices Laboratory

The Quantum Photonic Devices Laboratory is focused on advancing quantum information science and technologies through the development of novel quantum light sources and solid-state quantum devices. The researchers also test fundamental questions in quantum photonics.

Learn More

Quantum Simulation with Rydberg Atom Arrays

The Quantum Simulation Group provides access to quantum simulators as shared facilities to support fundamental research in condensed matter physics and accelerate the development of novel quantum materials. Our first-generation quantum simulator exploits strongly-interacting quantum many-body systems formed by two-dimensional configurations of neutral atoms excited to a Rydberg state, also known as Rydberg atom arrays.

Quantum Software Group (Qsoft)

As a growing array of quantum technologies are developed, the need for "quantum software" grows. The main focus of Qsoft: The Quantum Software group, is to develop a range of tools for the synthesis and optimization of quantum software to be run on fault-tolerant quantum computing hardware.

Learn More

Spin Engineering Lab

Spin 1/2 particles are nature's qubits. They are useful as building blocks of prototype quantum systems with applications to sensing, simulation and computation. Our interest is to engineer spin systems to further the development of coherent control and in particular to extend our knowledge of multi-body physics.

Learn More

INSTITUT QUANTIQUE UdS

Quantum Information

ALEXANDRE BLAIS
Directeur scientifique - Chaire MEI en architectures d'ordinateurs quantiques

EVA DUPONT-FERRIER

MAX HOFHEINZ

MATHIEU JUAN
Chaire de recherche en systèmes hybrides quantiques (CRSHQ)

STEFANOS KOURTIS
Chaire MEI en calcul quantique

BERTRAND REULET
Chaire de recherche du Canada sur le rayonnement micro-onde quantique

BAPTISTE ROYER
Chaire de recherche sur le contrôle de systèmes quantiques extensibles

DAVE TOUCHETTE

Quantum Materials

CRIS ADRIANO

CLAUDE BOURBONNAIS

RENÉ CÔTÉ

PATRICK FOURNIER

ION GARATE

MATHIEU MASSICOTTE
Chaire de recherche sur les nanomatériaux pour la photonique intégrée (CRNPI)

DENIS MORRIS

JEFFREY QUILLIAM

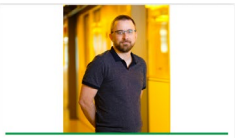
DAVID SÉNÉCHAL

LOUIS TAILLEFER
Chaire de recherche du Canada en matériaux quantiques

ANDRÉ-MARIE TREMBLAY
Chaire de recherche en théorie des matériaux quantiques

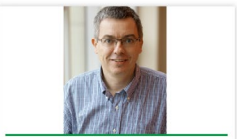
Quantum Engineering

VINCENT AIMEZ



YANN BEILLIARD

YVES BÉRUBÉ-LAUZIÈRE

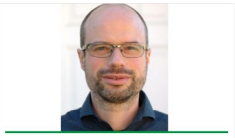


FRANÇOIS BOONE

PAUL CHARETTE
Chaire de recherche industrielle CRSNG-Teledyne DALSA pour les MEMS et microphotonique de prochaine génération

SERGE CHARLEBOIS

DOMINIQUE DROUIN
Chaire de recherche industrielle CRSNG-IBM Canada en encapsulation microélectronique pour l'échelonnement de la performance

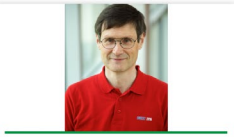


MAX HOFHEINZ

FRÉDÉRIC MAILHOT
Professeur agrégé

SYLVAIN NICOLAY

JEAN-FRANÇOIS PRATTE



JEAN ROUAT

Stewart Blusson
Quantum Matter Institute
THE UNIVERSITY OF BRITISH COLUMBIA

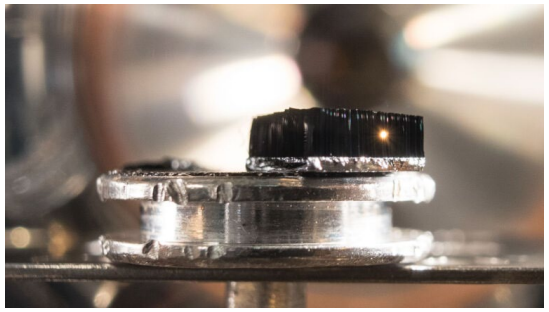
Research Themes

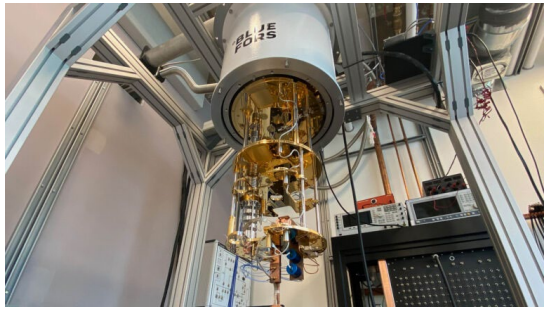
- Atomic Level Design of Quantum Materials
- Emergent Electronic Phenomena at Interfaces
- Topologically Protected Quantum States
- Photonic Manipulation of Quantum States

Grand Challenges

Engineering exotic phases in 2D materials

Atomistic approach to emergent properties of disordered materials





Pushing the boundaries of Noisy Intermediate Scale Quantum (NISQ) computing by Focusing on Quantum Materials

QUANTUM SCIENCE CENTER℠

Berkeley UNIVERSITY OF CALIFORNIA · Caltech · Fermilab · HARVARD UNIVERSITY

IBM · Infleqtion · Los Alamos NATIONAL LABORATORY EST.1943 · Microsoft

OAK RIDGE National Laboratory · Pacific Northwest NATIONAL LABORATORY · PRINCETON UNIVERSITY · PURDUE UNIVERSITY

UCLA · UCSB UNIVERSITY OF CALIFORNIA SANTA BARBARA · THE UNIVERSITY OF TENNESSEE KNOXVILLE · UNIVERSITY of WASHINGTON

Thrust 1: Quantum Materials Discovery and Development

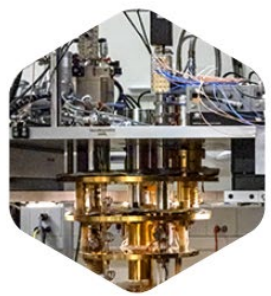
Thrust 1 demonstrates and controls non-Abelian anyon states relevant to Quantum Information Science (QIS) in real materials. These states are expected to exist in electronic materials with nontrivial topologies and magnetic systems with entangled quantum spins, and the topological protection and delocalization of the states that make them attractive for QIS applications can also make them difficult to probe and to understand. Thus, research in this thrust is focused on understanding and developing topological electronic materials, quantum spin systems, and quantum probes.

Led by ORNL's Michael McGuire

Thrust 2: Quantum Algorithms and Simulation

Thrust 2 achieves predictive capabilities for the study of strongly coupled quantum systems, including topological systems and quantum field theories, and develops and tests quantum algorithms for quantum-limited sensors. QSC researchers are developing efficient, scalable, and robust quantum simulation and metrology algorithms, testing these algorithms in predictive dynamical quantum simulation and quantum sensing applications, and developing software tools to support algorithm analysis, optimization, and implementation.

Led by LANL's Andrew Sornborger



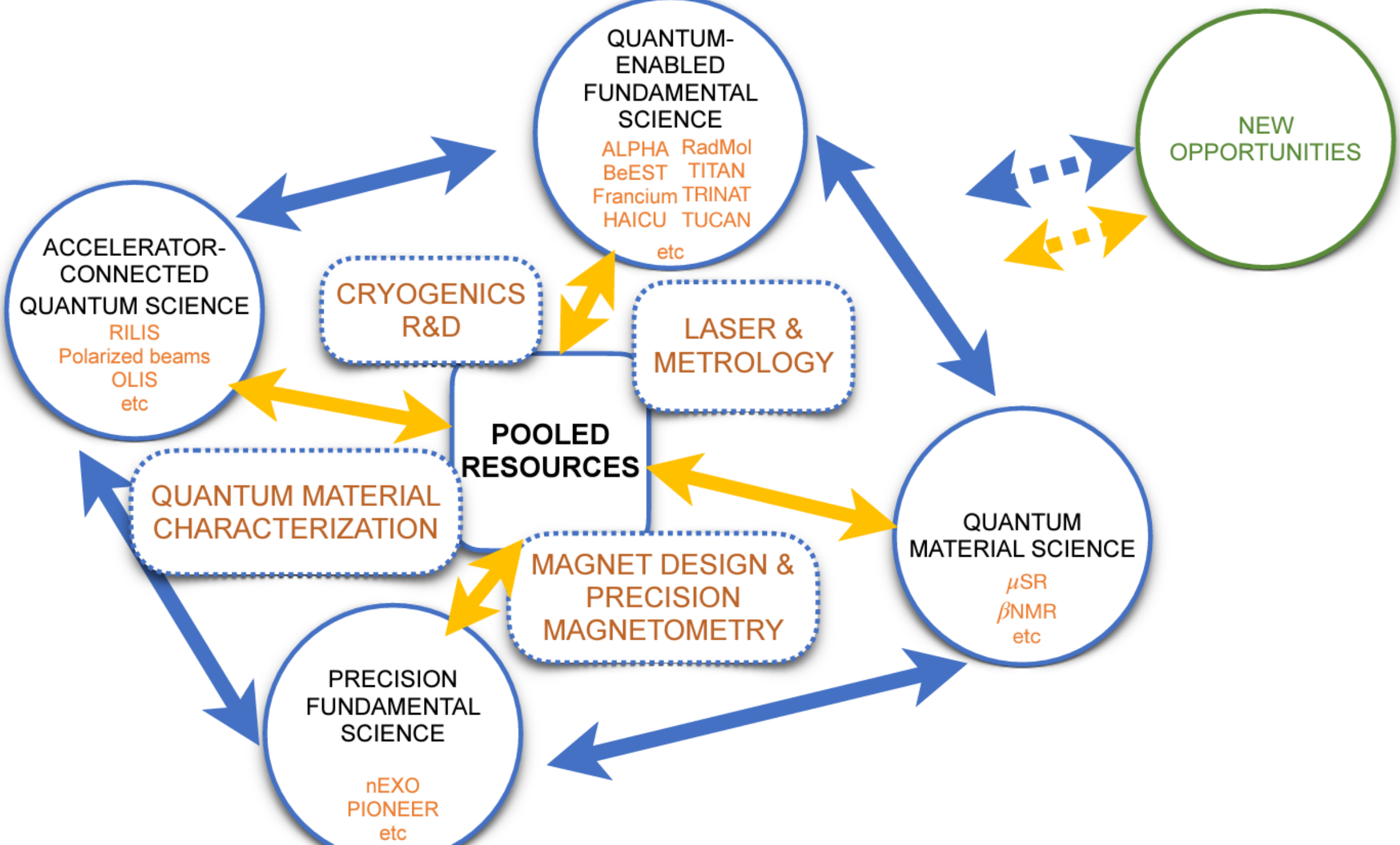
Thrust 3: Quantum Devices and Sensors for Discovery Science

Thrust 3 develops an understanding of fundamental sensing mechanisms in high-performance quantum devices and sensors. This understanding allows QSC researchers, working across the Center, to co-design new quantum devices and sensors with improved energy resolution, lower energy detection thresholds, better spatial and temporal resolution, lower noise, and lower error rates. Going beyond proof-of-principle demonstrations, the focus is on implementation of this hardware in specific, real-world applications.

Led by Fermilab's Aaron Chou

Explore and identify novel research directions for QST in other fields of science, including fundamental physics, cosmology, high-energy physics, and quantum chemistry.

Munich Center for Quantum Science and Technology


QUANTUM-ENABLED FUNDAMENTAL SCIENCE
ALPHA RadMol
BeEST TITAN
Francium TRINAT
HAICU TUCAN
etc
NEW OPPORTUNITIES
ACCELERATOR-CONNECTED QUANTUM SCIENCE
RILIS
Polarized beams
OLIS
etc
CRYOGENICS R&D
LASER & METROLOGY
POOLED RESOURCES
QUANTUM MATERIAL CHARACTERIZATION
MAGNET DESIGN & PRECISION MAGNETOMETRY
QUANTUM MATERIAL SCIENCE
μSR
βNMR
etc
PRECISION FUNDAMENTAL SCIENCE
nEXO
PIONEER
etc